

POLYAXIAL BONE SCREW WITH TORQUELESS FASTENING

Field of the Invention

This invention is directed to spinal implant systems and, in particular, to a multi-component adjustable implant system capable of maintaining a desired amount of torque between the skeletal bone and the implant.

Background of the Invention

For individuals with spinal pathologies, the development of spinal fixation devices represents a major medical breakthrough. Surgically implanted fixation systems are commonly used to correct a variety of back structure problems, including those which occur as a result of trauma or improper development during growth. These fixation systems typically include one or more stabilizing rods aligned in a desired orientation with respect to a patient's spine. Additionally, anchoring screws are inserted into the patient's spinal bones, and a series of connectors is used to rigidly link the rods and anchors.

A variety of designs exist, with each design addressing various aspects of the difficulties that arise when one reshapes an individual's spine to follow a preferred curvature. Unfortunately, known spinal implant systems often correct one set of problems only to create new ones.

1 Common to spinal implant systems is the necessity for
2 proper anchoring to the bone so as to provide support for the
3 aforementioned components. While bone screws are commonly used
4 for anchoring, they are limited in their positioning due to the
5 design of component pieces. Numerous patents are directed to
6 component design in order to accommodate the bone screw, yet
7 few patents are directed to bone screws that will accommodate
8 existing component design. In most bone screw designs
9 accommodation is made for applying anti-torque to the bone
10 screw as other components are connected to the bone screws.
11 This preserves the critical bone-screw interface which has been
12 set when the screw is turned into the bone.

13 For this and other reasons, screws located in bone
14 structure typically use a specially designed clamp to attach to
15 a component such as an alignment rod. A problem with specially
16 designed clamps is that bone structure cannot be determined
17 until the patient's bone is exposed causing the necessity of a
18 large inventory of various sized clamps to be on hand during
19 surgery, of which the surgeon must search to find the right
20 combination. Even if a clamp combination is predicted,
21 insertion of the screw may still require angular insertion due
22 to muscle or tender nerve locations. The result is a bone
23 screw which exerts unpredictable forces upon attachment to
24 component connectors. Further, any movement of muscle and

1 other tissue increases the difficulty of the operation and can
2 be a major trauma to a person.

3 A conventional bone screw consists of a single shaft with
4 a coarse thread at one end for threading into the bone and a
5 machine thread at the other end for coupling to components.
6 Another type of bone screw has a U-shaped top which acts as a
7 saddle for attachment to an alignment rod. If the screw is
8 placed incorrectly for any reason, the rod clamp must be made
9 to accommodate the position.

10 A number of patents exist which demonstrate the reliance
11 on the saddle type screw support and various designs to
12 accommodate the problem.

13 U.S. Patent No. 5,133,717 sets forth a sacral screw with
14 a saddle support. Disclosed is the use of an auxiliary angled
15 screw to provide the necessary support in placing the screw in
16 an angular position for improved anchoring.

17 U.S. Patent No. 5,129,900 sets forth an attachment screw
18 and connector member that is adjustably fastened to an
19 alignment rod. An oblong area provided within each connector
20 member allows minute displacement of the alignment rod.

21 U.S. Patent 4,887,595 discloses a screw that has a first
22 externally threaded portion for engagement with the bone and a
23 second externally threaded portion for engagement with a

1 locking nut. The disclosure illustrates the use of a singular
2 fixed shaft.

3 U.S. Patent 4,946,458 discloses a screw which employs a
4 spherical portion which is adapted to receive a locking pin so
5 as to allow one portion of the screw to rotate around the
6 spherical portion. A problem with the screw is the need for
7 the locking pin and the inability of the base screw to
8 accommodate a threaded extension bolt.

9 U.S. Patent 5,002,542 discloses a screw clamp wherein two
10 horizontally disposed sections are adapted to receive the head
11 of a pedicle screw for use in combination with a hook which
12 holds a support rod at an adjustable distance.

13 U.S. Patent 4,854,304 discloses the use of a screw with a
14 top portion that is adaptable for use with a specially designed
15 alignment rod to permit compression as well as distraction.

16 U.S. Patent 4,887,596 discloses a pedicle screw for use in
17 coupling an alignment rod to the spine wherein the screw
18 includes a clamp permitting adjustment of the angle between the
19 alignment rod and the screw.

20 U.S. Patent 4,836,196 discloses a screw with an upper
21 portion design for threadingly engaging a semi-spherical cup
22 for use with a specially designed alignment rod. The alignment
23 rod having spaced apart covertures for receipt of a spherical
24 disc allowing a support rod to be placed at angular positions.

1 U.S. Patent 5,800,435 sets forth a modular spinal plate
2 assembly for use with polyaxial pedicle screw implant devices.
3 The device includes compressible components that cooperatively
4 lock the device along included rails.

5 U.S. Patent 5,591,166 discloses an orthopedic bone bolt
6 and bone plate construction including a bone plate member and
7 a collection of fasteners. At least one of the fasteners
8 allows for multi-angle mounting configurations. The fasteners
9 also include threaded portions configured to engage a patient's
10 bone tissue.

11 U.S. Patent 5,569,247 discloses a multi-angle fastener
12 usable for connecting patient bone to other surgical implant
13 components. The '247 device includes fastening bolts having
14 spherical, multi-piece heads that allow for adjustment during
15 installation of the device.

16 U.S. Patent 5,716,357 discloses a spinal treatment and
17 long bone fixation apparatus. The apparatus includes link
18 members adapted to engage patient vertebrae. The link members
19 may be attached in a chain-like fashion to connect bones in a
20 non-linear arrangement. The apparatus also includes at least
21 one multi-directional attachment member for joining the link
22 members. This allows the apparatus to be used in forming a
23 spinal implant fixation system.

1 Another type of spinal fixation system includes rigid
2 screws that engage the posterior region of a patient's spine.
3 The screws are adapted with rod-engaging free ends to engage a
4 support rod that has been formed into a desired spine-
5 curvature-correcting orientation. Clamping members are often
6 used to lock the rod in place with respect to the screws.
7 Instead of clamping members, other fixation systems, such as
8 that disclosed in United States Patent No. 5,129,900, employ
9 connectors that join the support rods and anchoring screws.
10 The connectors eliminate unwanted relative motion between the
11 rod and the screws, thereby maintaining the patient's spine in
12 a corrected orientation.

13 Unfortunately, although these so-called "rigid screw"
14 fixation systems can alter the curvature of a patient's spine,
15 they can also be difficult to install. In this type of system,
16 the anchoring screws must be secured in a region that is
17 strong/rigid enough to support the characteristically-large
18 loads typically transferred from the support rods. As a
19 result, the number of suitable anchoring locations is limited.
20 Typically, these screws are anchored into the posterior region
21 of a patient's spinal column or into pedicle bone. With rigid
22 screw systems, installation requires bending a support rod into
23 a path that will not only correct the shape a patient's spine
24 but that will also engage each of the installed anchoring

1 screws. Achieving a proper fit between all of the components
2 while contending with the constraints encountered during
3 surgery is often difficult. In severe cases, a suitable fit
4 may not be achieved and the surgery will be unsuccessful.

5 Additionally, the nature of the installation process
6 required for rigid screw fixation systems often subjects the
7 system components to pre-loading that unduly stresses the
8 interface between the patient's bone and the employed anchoring
9 screws. With these designs, as a patient moves about during
10 daily life, the system components may become separated from the
11 supporting bone. Corrective surgery to reattach anchoring
12 screws exposes an already-weakened region to additional trauma
13 and presents the risk of additional damage.

14 Other spinal fixation systems employ adjustable
15 components. For example, United States Patent No. 5,549,608
16 includes anchoring screws that have pivoting free ends which
17 attach to discrete rod-engaging couplers. As a result, the
18 relative position of the anchoring screws and rods may be
19 adjusted to achieve a proper fit, even after the screw has been
20 anchored into a patient's spinal bone. This type of fixation
21 system succeeds in easing the rod-and-screw-linking process.
22 This adjustment capability allows the screws to accommodate
23 several rod paths. Unfortunately, some adjustable fixation
24 systems tolerate only limited amounts of relative adjustment

1 between components, operating best when loaded in one of
2 several preferred arrangements. As a result, many prior art
3 adjustable fixation systems are suitable for only a few
4 situations.

5 Additionally, many adjustable fixation systems are prone
6 to post-surgery component loosening. As a patient moves about
7 during day-to-day living, his spine is subjected to a
8 seemingly-endless amount of dynamic loading. Almost all
9 activity requires some form of back motion; over time, this
10 cyclic movement tends to work the components of many adjustable
11 fixation systems loose.

12 Some adjustable spinal fixation systems include locking
13 mechanisms designed for long-term, post-surgery securement of
14 the system components. Although capable of being locked in
15 place, these systems are often difficult to secure, requiring
16 an excess of tools during the installation process. The need
17 for extra tools, such as those required to shave, to apply
18 anti-torque, or crimp key portions of a fixation system,
19 increasing surgical risk by adding complexity and increasing
20 the number of required steps. Although locking-component
21 fixation systems exist, many of them unduly increase the
22 dangers of back implant surgery to an unacceptable level.

23 Hardware-intensive fasteners are disclosed in United
24 States Patent No. 5,549,608, in which anchoring screws are

1 fitted with wrenching flats that allow an anchoring screw to be
2 attached to a patient's spinal bone with the flats being
3 trimmed away once the screw is in place. Clamping nuts are
4 then used to secure the anchoring screws to included
5 stabilizing rods.

6 Additionally, many spinal fixation systems do not permit
7 component repairs. If, for example, a threaded portion of a
8 connecting member becomes stripped or cross-threaded, the
9 entire connector must be slid off of the associated stabilizing
10 rod. Often, such removal produces an undesirable "domino-
11 effect," requiring that several connectors be slid off to allow
12 removal of the damaged connector. Such requirements add
13 unnecessary difficulty to an already-complex procedure.

14 The bone screws shown and described in U. S. Patent No.
15 5,628,740 and U. S. Patent No. 6,050,997 have a bone screw with
16 a spherical cavity in the proximal end. A toggle bolt with a
17 spherical distal end is inserted into the cavity in the bone
18 screw. A collet is forced into the spherical cavity superior
19 to the spherical end of the toggle bolt. A support collar or
20 attachment cap is placed over the toggle bolt and tightened
21 down. This forces the retention collet to engage the spherical
22 portion of the toggle bolt and the inside of the spherical
23 cavity locking the toggle bolt in a selected angular
24 disposition. This system requires extremely accurate machining

1 of the threaded components to result in an optimum frictional
2 fit. Further, because the collet is a ring, with a fixed inner
3 diameter, there is only one correct size for the spherical
4 components. Finally, any deformation of the ring will lessen
5 the over-all frictional contact by creating wrinkles or ridges
6 on the collet.

7 U. S. Patent No. 4,419,026 to Leto discloses a split
8 ring camming internal locking device used with telescoping
9 tubular members for transporting liquids. The ring is split
10 for flexing to fit around the internal tube and for resiliently
11 sealing against the external tube.

12 Thus, what is needed is a spinal fixation system that
13 includes the advantages of known devices, while addressing the
14 shortcomings they exhibit. The system should allow component
15 adjustment during installation, thereby enabling satisfactory
16 correction of a wide variety of spinal deformities. The system
17 should also include a component locking mechanism that is
18 simple and reliable. The system should also include mounting
19 hardware that secures with a minimum of tools and that allows
20 modular replacement of components damaged during installation.
21 The system should also include tools and components for the
22 locking mechanism developing a compression fit between
23 components without additional torque on the bone-screw
24 interface.

1 Summary of the Invention

2 The present invention is fastening system for bone screws
3 used in spinal fixation systems for reshaping the spine of a
4 patient. The bone screw has threads on one end for anchoring
5 in the spine. The other end has a spherical connector with a
6 conical cavity therein. The cavity has the larger diameter
7 base of the cone toward the threaded end of the screw and a
8 narrower mouth. The mouth of the conical cavity accepts the
9 spherical end of a toggle bolt such that the toggle bolt and
10 the bone screw are connected by a ball joint. To prevent
11 disassembly of the bone screw and toggle bolt, an associated
12 split retention ring locking mechanism is inserted in the
13 conical cavity between the spherical end of the toggle bolt and
14 the mouth of the cavity. The resilient split retention ring
15 can be compressed to reduce it's diameter for insertion through
16 the mouth of the cavity and then expands to fill the conical
17 cavity superior to the spherical end of the toggle bolt.

18 Because of the flexibility and resilience of the split
19 retention ring, the mating parts do not require fine tolerances
20 and are less expensive to make. Further, the split retention
21 ring provides infinite adjustment of the locking pressure as
22 the toggle bolt is pushed into the assembly. The system is
23 modular, employing a collection of anchoring assemblies that
24 are linked, via various connectors, to strategically-arranged

1 stabilizing rods. The stabilizing rods are shaped and aligned
2 to impart a preferred curvature to a patient's spine.

3 The anchoring assemblies are multi-piece units
4 characterized by linking members that are joined in a ball-and-
5 socket-type arrangement with a corresponding bone-engaging
6 member. During use, the bone-engaging member is secured to a
7 spinal bone and the linking member is secured to one of the
8 stabilizing rods via a corresponding connector. The bone-
9 engaging member may include coarse, external threads or have a
10 hook-shaped end. Each anchoring assembly also includes a
11 support collar that provides a secure interface between the
12 bone-engaging member and associated connector. Each anchoring
13 assembly also includes a securing ring and a locking insert
14 that cooperate to prevent unwanted, post-installation motion
15 within the anchoring assembly. The securing ring and locking
16 insert also prevent unwanted relative motion between the
17 anchoring assembly and associated connector.

18 The connectors are rigid structures adapted to link an
19 associated anchoring assembly with one of the stabilizing rods.
20 In one embodiment, the connectors are two-piece constructions
21 that allow the connector to engage a stabilizing rod in a
22 sandwich-type arrangement, permitting connector installation
23 and removal that does not disturb adjacent connectors.

1 The stabilizing rods are rigid members shaped to form a
2 spine-curvature-correcting path. Attaching each anchoring
3 assembly, via connectors, to a stabilizing rod forces a
4 patient's back into a surgeon-chosen shape. Stabilizing rods
5 may be used singly, or in pairs, depending upon the type of
6 correction required. The rods vary in size, but typically
7 extend between at least two vertebrae.

8 The linear fastening system is capable of applying a
9 tensile load to the linking member while supplying a clamping
10 force for securing a connector. More specifically, the system
11 utilizes a cooperating collet member and a compression ring
12 member which are constructed and arranged to slip easily over
13 a linking member while in a first release position. The collet
14 member is constructed and arranged with an inner engaging
15 surface and an outer tapered compression surface, the
16 compression ring member being constructed and arranged with an
17 inner tapered compression surface preferably conjugate in shape
18 the outer surface of the collet member. The fastener system is
19 secured by sliding the compression member in a linear
20 overlapping fashion over the collet member, thereby utilizing
21 the conical surfaces to compress the collet member and place a
22 tensile load on the compression ring to grip the outer surface
23 of the linking member. In this manner, the linear fastener
24 system is capable of providing a secure connection between

1 multiple components without the need to apply rotational torque
2 to the assembly. The connection also allows full thread
3 engagement and a locking connection without the need for
4 plastic inserts or adhesives. When compared to traditional
5 threaded fasteners, the dual conical compression surfaces allow
6 very precise tensile loads to be applied to the shank member.
7

8 Accordingly, it is an objective of the present invention
9 to provide a fastener system for polyaxial bone screws that is
10 capable of securing multiple components into a single assembly
11 without the need to apply rotational torque to the assembly.

12 An additional objective of the present invention is to
13 provide a fastener system for polyaxial bone screws capable of
14 linear engagement and disengagement.

15 It is a further objective of the present invention to
16 provide a fastener system for polyaxial bone screws capable of
17 providing linear engagement to externally threaded surfaces and
18 the like.

19 It is another objective of the present invention to
20 provide a polyaxial bone screw assembly for a spinal fixation
21 system that permits component adjustment during installation,
22 thereby enabling satisfactory correction of a wide variety of
23 spinal deformities.

1 It is still another objective of the present invention to
2 provide a linearly actuated compression connection between the
3 components and the bone screw developing a strong secure
4 fastening without additional torque on the bone screw.

5 It is an additional objective of the present invention to
6 provide a bone screw assembly that includes a split ring
7 locking mechanism that is simple and reliable.

8 It is a further objective of the present invention to
9 provide a spinal fixation system that includes two-piece
10 connectors that may be mounted along, and removed from, a
11 support rod without requiring movement of adjacent connectors.

12 It is yet another objective of the present invention to
13 provide a spinal fixation system that includes mounting
14 hardware which requires a minimum number of tools.

15 It is also an objective of the present invention to
16 provide a spinal fixation system that allows modular
17 replacement of damaged components.

18 Other objects and advantages of this invention will become
19 apparent from the following description taken in conjunction
20 with the accompanying drawings wherein are set forth, by way of
21 illustration and example, certain embodiments of this
22 invention. The drawings constitute a part of this
23 specification and include exemplary embodiments of the present
24 invention and illustrate various objects and features thereof.

1 **Brief Description of the Drawings**

2 Figure 1 is a pictorial view of the spinal fixation system
3 of the present invention;

4 Figure 2 is a perspective view of a toggle-type anchoring
5 assembly used for spinal fixation utilizing the linear engaging
6 fastener of the instant invention;

7 Figure 3 is a perspective view of a saddle-type anchoring
8 assembly used for spinal fixation utilizing the linear engaging
9 fastener of the instant invention;

10 Figure 4 is a perspective view of a toggle-type polyaxial
11 bone-engaging screw having a support collar;

12 Figure 5 is a perspective view of a toggle-type anchoring
13 assembly having the support collar removed;

14 Figure 6 is a perspective view of a saddle-type polyaxial
15 bone-engaging screw;

16 Figure 7 is a pictorial view of a bone-engaging member
17 from an anchoring assembly of the present invention;

18 Figure 8 is a pictorial view of a linking member from an
19 anchoring assembly of the present invention;

20 Figure 9 is a pictorial view of a split retention ring of
21 the present invention;

22 Figure 10 is a section view illustrating one method of
23 assembling the present invention;

1 Figure 11 is a section view illustrating one method of
2 assembling the present invention; and

3 Figure 12 is a pictorial view illustrating one embodiment
4 of the collet utilized for linear engagement of the present
5 invention;

6 Figure 13 is a pictorial view illustrating one embodiment
7 of the collet utilized for linear engagement of the present
8 invention;

9 Figure 14 is a pictorial view illustrating one embodiment
10 of the collet utilized for linear engagement of the present
11 invention;

12 Figure 15 is a pictorial view illustrating one embodiment
13 of the compression ring utilized for linear engagement of the
14 present invention;

15 Figure 16 is a pictorial view illustrating one embodiment
16 of the compression ring utilized for linear engagement of the
17 present invention; and

18 Figure 17 is a pictorial view illustrating one embodiment
19 of the compression ring utilized for linear engagement of the
20 present invention.

21

22

1 **Detailed Description of the Preferred Embodiment**

2 It is to be understood that while a certain form of the
3 invention is illustrated, it is not to be limited to the
4 specific form or arrangement of parts herein described and
5 shown. It will be apparent to those skilled in the art that
6 various changes may be made without departing from the scope of
7 the invention and the invention is not to be considered limited
8 to what is shown in the drawings and described in the
9 specification.

10 Now with reference to Figure 1, the spinal fixation system
11 10 of the present invention is shown. By way of overview, the
12 Fixation System 10 includes a collection of polyaxial bone-
13 engaging anchoring assemblies 12 that are joined via connectors
14 14,14' to stabilizing rods 16, 16'. The specifics of the
15 spinal fixation system 10 will now be discussed in more detail.

16 With additional reference to Figures 2 and 3, illustrate
17 two common types of polyaxial anchoring assemblies 12
18 illustrated as the toggle bolt type polyaxial bone-screw 11
19 (FIG 2) and the saddle type polyaxial bone-screw 13 (FIG. 3).
20 Both types of polyaxial bone-screws are illustrated utilizing
21 the linear engaging fastener 100 of the instant invention.
22 Figures 4 through 6 show the toggle type polyaxial screw
23 assembly 11 with an associated support collar 18. The support
24 collar 18 is constructed and arranged to engage the outer

1 spherical surface 32 of the of the pedicle screw 20 when a
2 clamping force is applied to toggle bolt 42. In addition to
3 the support collar 18, each anchoring assembly 12 also includes
4 a pedicle screw 20. As shown in Figures 4, 5 and 7, each
5 pedicle screw 20 also includes a spherical end 28 spaced apart
6 from the threaded end 26 by a neck portion 30. The exterior 32
7 of the pedicle screw spherical end 28 is preferably contoured
8 for easy grasping. Within the toggle-type pedicle screw 11 the
9 interior of the screw spherical end 28 forms a retention cavity
10 34, discussed below. The entrance 36 to the retention cavity
11 34 is characterized by a securing lip 38 that extends radially
12 into the retention cavity 34.

13 Each toggle bolt 22, as shown in Figure 8, includes a
14 spherical end 40 and an opposite machined end 42. The
15 spherical end 40 may be spherical, conical, or tapered. The
16 machined end 42 may be formed with a helical thread, a series
17 of parallel flanges, circular ramps, knurled, or otherwise
18 altered to provide a gripping surface for the linear engaging
19 fastener 100. While the term, machined, is used the bolt may
20 be cast or molded or formed in other ways well known in the
21 art. As shown in Figure 5, the spherical end 40 of the toggle
22 bolt 22 is shaped and sized to fit inside the pedicle screw
23 retention cavity 34. Preferably, the interior of the retention
24 cavity is substantially conical but slightly larger dimensions

1 than the spherical contours of the toggle bolt spherical end
2 40.

3 With reference to Figure 9, the split retention ring 24
4 includes a gap 44 separating the opposite ends of the split
5 retention ring main body 46. As seen in Figure 5, the split
6 retention ring 24 is used as a bracing means to secure the
7 spherical end 40 of the toggle bolt 22 within the pedicle screw
8 retention cavity 34. More specifically, after the toggle bolt
9 spherical end 40 is placed within the pedicle screw retention
10 cavity 34, the split retention ring 24 is pushed through the
11 entrance 36 of the retention cavity 34 by reducing the gap 44
12 facilitating travel past the engagement lip 38, thereby
13 bringing the split retention ring main body 46 to rest against
14 the engagement lip by spring action resilience of the split
15 retention ring 24.

16 With this arrangement, the split retention ring 24 allows
17 pivotal movement of the toggle bolt 22 within the retention
18 cavity 34, while preventing removal of the toggle bolt
19 therefrom. Once the split retention ring 24 and toggle bolt 22
20 are in place, the machined end 42 of the toggle bolt is
21 inserted through a passthrough aperture 48 of the support
22 collar 18. This is shown in Figure 4.

23 Once the toggle bolt 22 has been passed through the
24 support collar passthrough aperture 48, the support collar 18

1 comes to rest against the pedicle screw ball end 28. Although
2 several shapes are possible, the interior of the support collar
3 18 preferably has a contour that matches the exterior 32 of the
4 pedicle screw ball end 28. This arrangement limits the
5 relative motion possible between the support collar 18 and the
6 toggle bolt 22, while allowing the toggle bolt ball end 40 to
7 rotate freely within the pedicle screw retention cavity 34.

8 With additional reference to Figures 4 and 8, the toggle
9 bolt may have internal threads 122 or a circular groove 123
10 around the perimeter of the toggle bolt 22. The internal
11 threads allow the insertion of a threaded stem 110 for the
12 linear compression tool 112, shown in Fig. 10. Figure 11
13 illustrates utilization of the circular groove 123 for an
14 alternate embodiment of the linear compression tool 112.
15 Alternative constructions which allow attachment of a linear
16 compression tool 112 may include, but should not be limited to
17 cross drilled holes, internal circular grooves, flats formed on
18 the end of the toggle bolt and the like.

19 Still referring to FIGS. 10 and 11, the linear tensile
20 force and associated clamping force applied by an engaged
21 linear fastener 100 on the toggle bolt machined end 42 forces
22 relative longitudinal travel through the passthrough aperture
23 84 and causes the toggle bolt spherical end 40 to be forced
24 against the split retention ring 24 (FIGS 4-9) reducing the gap

1 44. Further equal and opposite linear engagement on the collet
2 116 by compression ring 117 forms a substantially rigid fit
3 between the toggle bolt 22 and the pedicle screw 20 without
4 torque being applied to the flexible joint or the bone-screw
5 interface. With the collet 116 compressed appropriately, the
6 toggle bolt machined end 42 is locked in place with regard to
7 the right-facing straight connector attachment flange 82, and
8 the toggle bolt spherical end 40 is locked in place within the
9 pedicle screw retention cavity 34. In this state, the split
10 retention ring is sandwiched between the exterior of the toggle
11 bolt ball end 40 and the conical interior of the retention
12 cavity 34. Since the split retention ring 24 is locked within
13 the retention cavity 34 by the retention cavity engagement lip
14 38, relative motion between the toggle bolt spherical end and
15 the pedicle screw 20 is prevented once the toggle bolt machined
16 end 42 is locked in place by the collet 116 and compression
17 ring 117. This results in a rigid link between the right-
18 facing straight connector and the anchoring assembly 12.

19 Although the above description refers to joining an
20 anchoring assembly 12 specifically to a right-facing straight
21 connector 52, each of the one-piece connectors 14 and two-piece
22 connectors 14' may be attached to an anchoring assembly in a
23 similar manner. That is, right-facing offset connectors are
24 attached by inserting a toggle bolt threaded end through the

1 associated passthrough aperture; left-facing offset connectors
2 are joined with an anchoring assembly by inserting a toggle
3 bolt threaded end through an associated passthrough aperture;
4 and left-facing straight connectors are attached to anchoring
5 assemblies by inserting a toggle bolt threaded end through an
6 associated passthrough aperture. In each case, the exterior
7 connectors 120 of the inserted toggle bolt threaded end 42 are
8 held in place by a compressed collet 116, as described
9 previously.

10 Now with reference to Figures 10 and 11, alternate
11 embodiments of an anchoring assembly 12' are shown with the
12 linear compression tool 112 in place securing the toggle bolt
13 22' to pedicle screw 20'. In one of these embodiments, the
14 toggle bolt 22' has an extension with a groove 123 beyond the
15 threaded end 42' which serves as a bit to be connected to a
16 linear compression tool 112, shown in Fig. 10. A collet 116 is
17 placed about the threaded end 42'. The collet 116 has a
18 cooperating internal surface 118 matching the configuration of
19 the machined end 42. The outer surface of the collet is
20 tapered with a larger base resting on the flange 82. The
21 groove 123 is connected to the tool 112 in a manner to apply
22 linear force in a direction away from the screw 20'. The
23 linear compression tool has an outer barrel 202 telescopically
24 surrounding the extension 201. The tool 112 applies an equal

1 and opposite linear force to the barrel and groove,
2 simultaneously. The barrel 202 engages the tapered compression
3 ring 117 to force the compression ring 117 over the collet 116
4 thereby completing a rigid compression fit. The toggle bolt 22
5 may be constructed having an integrally formed extension with
6 a frangible area (not shown) adjacent the machined end 42' or
7 alternatively a threaded stem may be secured to the threaded
8 internal cavity 122. Once the linear engagement is secured,
9 the barrel of the tool 112 can be used to sever the extension
10 or the threaded stem may be removed manually.

11 The collet member 116 shown in Figures 12 through 14, is
12 slid or loosely threaded over the external machined end 42 of
13 a linking member 22 or a U-shaped saddle member 150 generally
14 shown in Figures 4 through 6. To facilitate compression, the
15 collet member is provided with at least one slot 128 extending
16 completely through the collet and preferably includes a
17 plurality of partial slots 130. The external surface 120 of
18 collet member 116 is tapered or conical in form. The internal
19 gripping surface 118 of collet member 116 is generally
20 constructed and arranged to have a conjugate surface to the
21 machined surface 42 of the linking member 22 or the U-shaped
22 saddle member 150 for cooperative engagement therebetween. In
23 addition, the internal gripping surface 118 of the collet
24 member may be constructed and arranged to exert a tensile force

1 on the toggle or saddle members when compressed. This
2 construction allows precise clamping forces to be applied to an
3 assembly, allows full surface engagement between the toggle or
4 saddle member and the collet member, and facilitates a locking
5 connection without inserts or adhesive. The collet member 116
6 may also include a flared base 82 suitable to distribute
7 clamping force over a wide area or provide a load bearing
8 surface for adjacent components.

9 Referring to figures 15-18, The compression ring 117,
10 shown in Figures 15 through 17, has a tapered interior surface
11 122 which is complementary to the taper of collet member 116.
12 The compression ring 117 may be constructed with a flange 124
13 about the upper surface. The flange 124 may have optional lugs
14 124 formed in a C-shape for engaging an extractor (not shown)
15 used to remove or disconnect the coupling. The flange may also
16 have optional wrench flats 126 for engaging wrenches and/or
17 sockets that are well known in the art.

18 Referring to Figures 1 through 17, the spinal fixation
19 system 10 is preferably formed from rigid, biocompatible
20 materials. One such preferred material is titanium; however,
21 other materials well known in the art may also be used.

22 Although the invention has been described in terms of a
23 specific embodiment, it will be readily apparent to those
24 skilled in this art that various modifications, rearrangements

1 and substitutions can be made without departing from the spirit
2 of the invention. The scope of the invention is defined by the
3 claims appended hereto.